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(54) Protective coating

(57) A titanium or titanium alloy component is provided with a protective coating by the steps of:
(a) electroplating a nickel or cobalt coating on the component surface
(b) electroplating a chromium coating on to the nickel or cobalt coating and
(c) heat treating the electroplated component at a temperature of 700°C under vacuum.
The resultant coating provides resistance to oxidation and alpha phase formation in the component.

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SPECIFICATION

Protective coating

This invention relates to protective coatings and has particular reference to protective coatings for titanium and alloys thereof.

Certain components of gas turbine engines, such as compressor blades, are frequently manufactured from titanium alloys. Such alloys are well suited to operation at temperatures ranging from well below 0°C up to in the region of 500°C. This means that the alloys can be used in all but the highest pressure stages of an axial flow gas turbine engine compressor. However other, usually ferrous, or nickel base alloys must be used in the highest pressure stages because of the high operating temperatures which they are likely to encounter. The use of such alloys is undesirable in view of the weight disadvantage which they have over titanium alloys. There are however, high strength titanium alloys now available which are capable of withstanding temperatures in excess of 500°C. Unfortunately at these temperatures, the alloys tend to oxidise and produce surface scaling as well as being prone to alpha phase formation due to their absorbtion of oxygen.

It is therefore an object of the present invention to provide protective coating for titanium and titanium alloys which renders the titanium or titanium alloy less prone to surface scaling and alpha phase formation at elevated temperatures then has heretofore been achieved.

According to the present invention, a method of providing a component formed from titanium or a titanium alloy with a protective coating comprises the steps of

a) depositing a coating of nickel or cobalt on said titanium alloy component surface

b) depositing a coating of chromium on said nickel or cobalt base coating and

c) heat treating said coated titanium or titanium alloy component under non-oxidising conditions to provide at least some interdiffusion between said deposited nickel or cobalt and chromium coatings and between said nickel or cobalt coating and the surface of said titanium or titanium alloy component.

The nickel or cobalt and chromium coatings may be applied by any convenient method. We prefer to apply them by electroplating in which case it is necessary to etch the titanium or titanium alloy component surface prior to the electroplating operation being carried out. The necessary degree of etching can be achieved by anodically etching the component surface in a mixture of acetic acid and hydrofluoric acid. Other methods of deposition of the nickel or cobalt and chromium coatings could however be employed if so desired. Thus the coatings could be deposited by such techniques as physical vapour deposition or electroless deposition.

Although the heat treatment step to provide interdiffusion may be carried out in any atmosphere which is non-oxidising and which does not have a detrimental effect upon the coated component, we pefer to carry out the step under vacuum.

In order to demonstrate the efficacy of the present invention, a titanium alloy test piece was coated in accordance with the method of the present invention and then subjected to testing in a high temperature environment. More specifically a pin 50 mm long and 7 mm diameter formed from the commercially available alloy known as Ti5331S was initially anodically etched in a mixture containing 87.5 percent by volume acetic acid and 12.5 percent by volume hydrofluoric acid at a current density of 1.8 A/m^2 at a temperature of 40–50°C for one minute. Ti5331S is produced by Imperial Metal Industries and contains by weight 5.5% aluminium, 3.5% tin, 3% zirconium and 1% niobium the balance being titanium.

The pin was then rinsed before being electroplated with nickel to a depth of 20–25 um. The electroplating was carried out in a modified Watts bath for a period of 20 minutes at a temperature of 50° and a current density of 4.5 A/m^2. After further rinsing, the pin was electroplated with chromium to a depth of 1–2 um. The electroplating was carried out in a bath containing 375 grams/litre chromic acid and 2.5 grams/litre sulphuric acid for a period of 5 minutes at a temperature of 49°C and a current density of 20.7 A/m^2. The pin with its electroplated coatings of nickel and chromium was then rinsed and dried before being heated at a temperature of 700°C for one hour under vacuum to provide a certain degree of interdiffusion of the nickel and chromium coatings as well as to ensure a certain degree of interdiffusion between the nickel coating and the titanium alloy of the pin to provide an effective inerfacial bond between the pin and the coatings.

The pin was then heated in air at a temperature of 650°C for a period of 1000 hours in order to assess the performance of the applied coating at prolonged high temperatures. It was found upon sectioning the pin that there was only superficial oxidation of the surface of the titanium alloy pin and that there was no evidence of alpha phase formation.

Although in the above example, the test piece was a titanium alloy pin electroplated with nickel and chromium, it will be appreciated that the method of the present invention is applicable to the protection of titanium or other titanium alloys and that a cobalt coating could be substituted for the nickel if so desired.

The present invention therefore provides a useful method of protecting titanium or titanium alloy components which in use are subject

to high ambient temperatures, from the effects of oxidation and alpha phase formation.

CLAIMS

1. A method of providing a component formed from titanium or a titanium alloy with a protective coating comprising the steps of:

a) depositing a coating of nickel or cobalt on said titanium or titanium alloy surface

b) depositing a coating of chromium on said nickel or cobalt coating and

c) heat treating said titanium or titanium alloy component under non-oxidising conditions to provide at least some interdiffusion between said deposited nickel or cobalt and chromium coatings and between said nickel or cobalt coating and the surface of said titanium or titanium alloy component.

2. A method of providing a component formed from titanium or a titanium alloy with a protective coating as claimed in claim 1 wherein said nickel or cobalt and chromium coatings are deposited on said component surface by electroplating.

3. A method of providing a component formed from titanium or a titanium alloy with a protective coating as claimed in claim 1 or claim 2 wherein said heat treatment of said titanium or titanium alloy component is carried out under vacuum.

4. A method of providing a component formed from titanium or a titanium alloy with a protective coating as claimed in any one preceding claim wherein said heat treatment of said titanium or titanium alloy component is carried at a temperature of approximately 700°C for a period of approximately one hour.

5. A method of providing a component formed from titanium or a titanium alloy with a protective coating as claimed in any one preceding claim wherein said nickel or cobalt coating is deposited to a depth from 20 to 25 um and said chromium coating is deposited to a depth of from 1 to 2 um.

6. A method of providing a component formed from titanium or a titanium alloy with a protective coating substantially as hereinbefore described with reference to the accompanying example.

7. A component formed from titanium or a titanium alloy provided with a protective coating by the method of any one preceding claim.

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